REMARKS

Claims 1-12, 16-19 and 21-28 are pending in the above-referenced patent application. All of the claims were rejected in the Final Rejection dated February 25, 2004 and the Advisory Action of May 24, 2004. Claims 1-12, 16-19 and 21-23 were rejected under 35 U.S.C. 112, second paragraph, because the Patent Office states that in regards to Claim 1: (1) the term "interdependencies between said stored maps and interdependencies between submapss of stored maps" is not clear, (2) it is not clear whether "tolerance map" refers to accumulation maps, or functional maps, or both. Dependent Claims 2-12, 16-19, 21-23 and 25-28 were rejected for the same reasons as Claim 1. Claim 1 was rejected under 35 USC 102(b) as being anticipated by USPN 5,586,052 to Iannuzzi et al. (hereinafter "Iannuzzi"). Rejection of Claim 1 is respectfully traversed because Iannuzzi does not disclose all of the claimed limitations. Claims 24-28 were rejected under 35 USC 103(a) as being unpatenable over commercial software in view of Maxey (AutoCAD). Rejection of Claims 24-28 is respectfully traversed because the Maxey does not disclose or suggest all of the claimed limitations.

Rejection of Claims 1-12, 16-19 and 21-23 under 35 U.S.C. 112

Claims 1-12, 16-19 and 21-23 were rejected under 35 U.S.C. 112, second paragraph, because the Patent Office states that in regards to Claim 1: (1) the term "interdependencies between said stored maps and interdependencies between submaps of stored maps" is not clear, (2) it is not clear whether "tolerance map" refers to accumulation maps, or functional maps, or both. Regarding "tolerance maps", "accumulations maps" and "functional maps", it is respectfully submitted that in the

Reply to the Office Action of Oct. 27, 2003 (paragraph spanning pages 13 and 14), it was stated that both functional maps and accumulation maps are tolerance maps in which the tolerances are selected such that any accumulation map is inside its corresponding functional map. As such, accumulation maps and functional maps are subspecies of tolerance maps as defined. Further, Claim 1 has been amended to discuss that tolerance zones include subzones and that submaps correspond to subzones. As such, it is respectfully submitted that all of the rejections under 35 U.S.C. 112 should be withdrawn.

Rejection of Claim 1 under 35 U.S.C. 102(b)

Applicant wishes to thank the Examiner for courtesies shown to Michael Zarrabian (Reg. No. 39,886) during the telephonic interview of June 15, 2004, in which the claimed invention was discussed. As a result of the telephone interview, Claim 1 has been further amended to more clearly define the claimed invention.

There are at least two sets of limitations in Claim 1 which are not disclosed by Iannuzzi. The first set of limitations is directed to a representation method based on a novel mathematical model, and the second set of limitations is directed to a tolerance evaluation method utilizing that mathematical model. Importantly, Iannuzzi's rule-based method for evaluating designs for correctness and completeness, takes place before, not in place of, the mathematical modeling and tolerance evaluation methods of the present invention.

Specifically, regarding said first set of claimed limitations, Iannuzzi does not disclose mathematical modeling as claimed herein. Iannuzzi's process is what takes place before a mathematical modeling process according to the present invention. Iannuzzi's concern is establishing relationships between the input data (i.e., data representing features and data representing tolerances of features) and determining degrees of freedom for the features and tolerances, to check if the tolerance plan defined by a designer is complete and well formed (Abstract). If the tolerance plan is complete and well formed then a mathematical model can be generated, however, Iannuzzi is not concerned with generating such a mathematical model. The process of the present invention in generating such a mathematical model is what takes place after Iannuzzi's data checking process is done. Iannuzzi does not generate a mathematical model for tolerance zones according to the present invention, rather Iannuzzi checks the input data (i.e., tolerance plan) which can later be used in a mathematical modeling method as claimed herein.

This is clear from Iannuzzi, col. 12, line 65 to col. 13, line 10, where Iannuzzi states:

> "If all of the possible degrees of freedom for a particular feature are, consistent with the tolerance rule set, controlled 48, then the tolerance plan for that feature is considered well defined, and a mathematical model of the tolerance plan for that feature can be generated based on the tolerance rule set and without assumptions. If after the comparisons are made, however, all of the possible degrees of freedom of the feature are not, consistent with the tolerance rule set, controlled 49, e.g., no tolerances or conflicting tolerances are assigned or an incomplete or undefined DRF is referenced, then the tolerance plan is not considered well defined. The DOF tester 28 warns the via the user interface 16. In this case, assumptions are required to generate a mathematical model of the tolerance representation."

Iannuzzi does not disclose a mathematical modeling method that allows evaluating tolerances of computer assisted designs for the manufacture of objects comprising. According to the claimed invention herein, such a method for each object includes the steps of: "representing each tolerance zone for each geometric feature of said object by a model with an algebraic form and a geometric form, wherein the geometric form is represented as a tolerance map stored in a computer, each tolerance map comprising a hypothetical space of points that describes the acceptable positions of a surface of the object, wherein the tolerance map is a mapping of physical space into the hypothetical space of points such that the shape and size of the hypothetical space of points are functions of the tolerance zone," as required by Claim 1.

Iannuzzi is not concerned with a representation model as claimed. In its Background section, Iannuzzi lays out the problem to be solved. Specifically, in col. 1, line 12 to col. 3, line 7, Iannuzzi states (in relevant parts):

> "All manufactured products or parts are subject to variation of their various features, i.e., surfaces, holes, etc., as a result of the manufacturing processes used to create them. The variation in these features compounds as a result of bringing several manufactured parts together to make an assembly. *Designers try to control variation by establishing a tolerance plan which specifies how much variation may exist on a particular part.* Deficiencies in the tolerance plan, however, often do not become apparent until proto-type pads are constructed, checking fixtures and gages are designed or constructed, and/or pads are manufactured.... *Therefore, it is important to verify early on, while the parts are being designed, that the tolerance plan is well formed.*
> A difficulty with assigning tolerances to features on a part lies in the measuring of "what" from "where". Often the datum or reference feature from which a tolerance is defined has no relation to the feature being measured.... *Thus it is important to have a well defined tolerance plan to identify for the manufacturer an acceptable range of variation for particular features of a part or assembly such that the part or assembly will function as intended. Rules for assigning these tolerances assist in this*

effort by providing a consistent interpretation of what the designer meant by a particular tolerance assignment....

The tolerance plan can further be thought of as measurement criteria. The tolerance plan defines what is being measured and from where it is being measured. In this regard, tolerance rules generally require definition of an initial feature or datum from which measurements originate. ... The tolerance rules also provide for assigning a magnitude of allowable variation for each of the features assigned a tolerance....

Tolerances, similar to basic dimensions, define allowable amounts of variation for a particular feature ....

Basic dimensions place a fixed constraint on the relationship, e.g., the position of surface "A" is a fixed number of millimeters away from surface "B" in the "X" direction. Tolerances place a variable constraint on the relationship, e.g., the position of surface "A" may vary plus or minus so many millimeters from surface "B" in the "X" direction. For consistency, basic dimensions are referred herein as constraints or constraining data and tolerances are referred to as relaxations or relaxing data....

Degrees of freedom help the understanding of how tolerances relax constraints in three dimensional space. For example, a cylinder representing a hole through the surface of a part is defined by certain fixed data which identify the location, orientation, size and form of the hole. Variation of some of this data effects the location and orientation of the feature. These are degrees of freedom of the feature. *Tolerances permit but also define limits on the amount of variation of the fixed data. Thus the tolerances control the feature degrees of freedom.*

However, if a tolerance is not assigned, there are a number of possible interpretations. One interpretation is that the feature is perfect, that is, it must be assumed that there is no variation of the data defining the feature or no degrees of freedom. This further implies that there is no variation of this feature on the actual manufactured part, a condition which is not likely. Another interpretation is that large amounts of variation of the feature are acceptable or no control of the degrees of freedom. This, however, is only an assumption, and large amounts of variation may render the part useless." (emphasis added).

As can be seen from the above passage, Iannuzzi defines a tolerance plan as measurement criteria which defines what is being measured and from where it is being measured. Iannuzzi then states that sometimes designers do not assign all of the necessary tolerances in a tolerance plan and that it is important to verify early on, while the parts are being designed, that the tolerance plan is well formed. Accordingly,

Iannuzzi provides a for inputting data representing features of a manufactured part and data representing datums and tolerances for the features, establishing relationships between the data and determining the degrees of freedom for part features and tolerances to check if the tolerance plan defined by a designer is complete and well formed with respect to a given set of completeness and well formedness criteria (col. 3, lines 9-23). Iannuzzi does not disclose a mathematical model for representing each tolerance zone for each geometric feature of an object, as claimed. Iannuzzi's process is what takes place before a mathematical model is formed according to the present invention.

Further, Iannuzzi does not disclose the second set of claimed limitations, including the steps of: "computing in said computer interdependencies between said stored maps and interdependencies between submaps of said stored maps to determine how different tolerance zones for said geometric feature affect each other and to determine how different tolerance zones for different geometric features of said object affect each other, wherein a tolerance zone includes subzones and submaps correspond to subzones of tolerance zones; determining how different tolerance zones for geometric features on different objects affect each other; and selecting tolerance conditions for said object to optimize allocation of tolerances to each of said geometric features of said object or objects," as required by Claim 1.

Iannuzzi does not provide tolerance analysis which is the problem addressed by the present invention. Iannuzzi simply determines if a tolerance plan as defined by input datum is complete and well formed. Iannuzzi does not disclose tolerance analysis using a

mathematical model as claimed. For example, Iannuzzi does not consider the issue of accumulation at all, rather Iannuzzi looks only at tolerance specification, not how the errors "stack up" or accumulate as parts are put together. Tolerance analysis involves the accumulation of error when imperfect parts are put together (i.e., stackup problem). Iannuzzi does not in any way deal with tolerance analysis and the accumulation problem as claimed herein.

However, according to the present invention, tolerance maps for objects are provided, wherein a primary function of the tolerance maps is to determine accumulation of errors. Iannuzzi only determines if a tolerance plan as defined by input data is complete and well formed, before tolerance analysis of any kind can be performed.

Further, Iannuzzi does not disclose a mathematical method (for instance, minimizing unused volume) as a means to optimize allocation of tolerances by: "selecting tolerance conditions for said object to optimize allocation of tolerances to each of said geometric features of said object," as required by Claim 1. In one example, optimizing amounts to selecting tolerances so that unused volume is minimized between two tolerance maps. Further, in contrast to Iannuzzi, according to the claimed invention tolerances can be evaluated on a computer by quantitative analysis using tolerance maps, wherein the size and shape of tolerance zones resulting from accumulation of variations in the tolerance maps are considered. Iannuzzi does not disclose accumulation of tolerances in stackup, i.e. there is no method provided on how tolerances in a dimension loop accumulate. Iannuzzi does not consider tolerance zones at all (neither the shape nor

size). Iannuzzi does not disclose any quantitative analysis of the effect of different tolerances on the size, shape and juxtaposition of tolerance zones resulting from several tolerances applied to the same feature. And, Iannuzzi has absolutely no overlap with either the application or the techniques used for our creating local models according to the present invention.

The Office Action states that the claimed limitation of representing each tolerance zone for each geometric feature of said object by a model with an algebraic form and a geometric form as a tolerance map (Claim 1) is disclosed by Iannuzzi at abstract "input of geometric data representing features of a manufactured part and data representing datums and tolerances for features". Applicant respectfully traverses this interpretation of Iannuzzi. As discussed, the passage in Iannuzzi to refers to checking tolerance plan data, not mathematical modeling or tolerance evaluation as claimed herein.

The Office Action states that computing interdependencies between said stored maps and interdependencies between submaps of said stored maps to determine how different tolerance zones for said geometric feature affect each other and to determine how different tolerance zones for different geometric features of said object affect each other (Claim 1) is disclosed by Iannuzzi at abstract "Relationships are established between the data and degrees of freedom are determined for the part features and tolerances." Applicant respectfully traverses this interpretation of Iannuzzi. As noted, Iannuzzi does not utilize tolerance zones or tolerance maps. Iannuzzi only verifies input data.

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The Office Action further states that selecting tolerance conditions for said object to optimize allocation of tolerances to each of said geometric features of said object (Claim 1) is disclosed by Iannuzzi at abstract "determine if the tolerance plan defined by a designer is complete and well formed. If it is not, the designer may then revise the tolerance plan to provide for a more consistent and useful tolerancing plan resulting in higher quality, lower cost manufactured parts and assemblies". Applicant respectfully traverses this interpretation of Iannuzzi because Iannuzzi does not disclose the claimed optimization step. As noted, "complete and well formed" as required by Iannuzzi, does not teach or suggest "optimal" as required by Claim 1. To be optimal, a design must meet more than just the minimum requirements (complete and well formed), and essentially be the best possible. For example, to design a structural beam to carry a fixed load over a given span, it is desired to determine the cross section and dimensions of the beam that allows the beam to carry the fixed load. The beam shape can be, e.g., an I-beam, a channel, a box beam, a pipe, etc. The present invention allows determining the proper dimensions for any of these beam shapes such that the beam will be strong enough to carry the load. As such, they are all valid solutions to the problem, but which one of the beam shapes will be the lightest weight (use the least material)? The search for the best beam shape from the point of view of design objective (lowest weight) is called optimization according to the present invention as claimed.

Iannuzzi uses a Rule based (Heuristic) method to determine degrees of freedom. By contrast, according to the present invention as claimed, a mathematical formulation of

the constraint relations and numerical methods for constraint solving (not symbolic manipulation of rules) are used. Therefore, for at least the above reasons, it is respectfully submitted that Claim 1, and all claims dependent therefrom, should be allowed.

Claim Rejections Under 35 U.S.C. 103(a)

The rejection of Claim 24 under 35 U.S.C. 103(a) as being unpatenable over commercial software in view of Maxey (AutoCAD) is respectfully traversed because as discussed below, Claim 24 includes limitations not taught or suggested by the references, alone, or in combination. Maxey (AutoCAD), referenced by the Examiner, only provides specification of Dimensioning & Tolernacing scheme in Auto CAD R13. Auto CAD is a popular software package for computer-assisted drawing. The dimension lines and tolerance frames created in Auto CAD are just symbols. One can create any type of tolerance frame, valid or invalid, attach it to any type of entity, whether it makes sense or not, and specify any kind of sensible or nonsensical DRF. Auto CAD (and other CAD systems like it) have no instrument to determine if the specified GD&T are valid (or even the drawing represents a physically realizable part). The invention in Claim 24 discloses a model that provides such an instrument. Modules E1, E2, E3 are commercial software, and modules M1, M2 are standard input modules.

AutoCAD only allows mark-up of drawings with text and symbols. There is no math model to even validate if the scheme makes sense. For example, AutoCAD allows specifying a flatness tolerance on a cylindrical surface or to specify two parallel planes as datums for setting up a coordinate system, or specify a form tolerance greater than size

tolerance. None of such specifications make sense. The reason AutoCAD will allow such nonsense specifications is that there is no math model in AutoCAD to validate the specifications. The symbols and text are simply stored as attributes of the entities, just like the color of a line. Interpreting AutoCAD to support tolerance analysis would be similar to interpreting Adobe Illustrator, MS/Word Picture Drawing tools or MACDraw (which enable drawing lines and boxes), to support electrical circuit analysis.

Further, with respect to the Applicant "admissions" the Patent Office mentions in the Office Action in rejection Claim 24, it is respectfully submitted that three types of commercially available software are needed to implement a tolerance modeling system according to an embodiment the present invention in Claim 24. These are indicated by the designations "E1", E2", and "E3" (e.g., Fig. 18 of original specification). Many different companies market these packages which offer comparable capabilities. However, the other modules in Claim 24 are not such. Modules M3, M4, M6 and M7 in conjunction with modules E1, E2, E3, M1, M2 and optimal module M5, provide the novel features of the claimed invention. As such, it is respectfully submitted that rejection of Claim 24 be withdrawn.
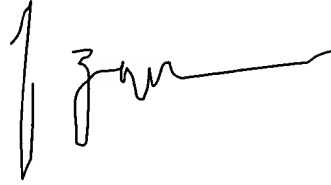
Conclusion

For the above reasons, and other reasons, it is respectfully submitted that rejection of the claims should be withdrawn. Reexamination, reconsideration and allowance of all claims are respectfully requested.

Please continue to send all communications to the agent of record.

Dated: June 24, 2004

Respectfully submitted,

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